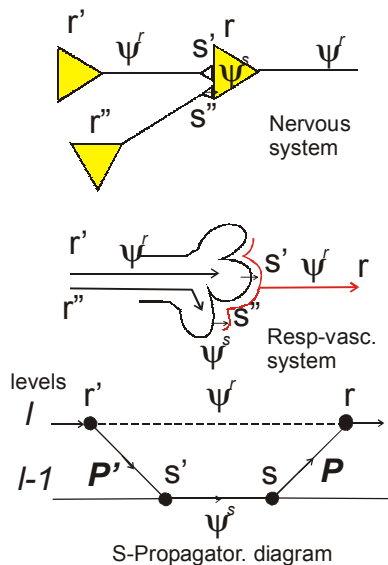


# **A Method for Integrating Physiological Mechanisms by Means of a Formalism To Traverse Levels of Organization**

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The integration of physiological functions in living organisms corresponds to the reconstruction of a biological system from its components. This calls for a sound theoretical framework based on the rigorous definition of the elementary physiological function within the context of multiple levels of biological organization. Modeling biological phenomena requires the coupling of different systems, e.g. the vascular and the nervous systems, and then a general theory to integrate them. Such a theory requires first a specific *representation*, and second a specific *formalism* to handle symbols in this representation [1].



I have chosen to represent the biological system in terms of *functional interactions*, classified according to their time scales (functions) and space scales (structures). The basic idea behind this representation is that a certain product  $\psi^r$  emitted by one structural unit (the source at  $r'$ , see *figure*) acts on another (the sink at  $r$ ) situated at a certain distance in the space of units. The formal biological system is then viewed as a combination of such interactions, which constitutes its functional organization (called the O-FBS). Because of the same generic diagram, there are two consequences:

(i) whatever the systems, the set of interactions between all elementary mechanisms is formalized under the form of a mathematical hierarchical graph; (ii) the  $n$ -field theory applied to these systems by means of the S-propagator formalism provides the functional interaction to traverse the levels of structural organization, and thus gives rise to the dynamics of the systems (called the D-FBS). The S-propagator, which allows the functional interaction  $\psi^r$  to act from  $r'$  onto  $r$ , is the product of three operators (see *figure*): (i) the *trans*-operator  $P'$ , which acts at  $r'$  causing the interaction to move down from the observed level to the next lower level; (ii) the *in*-operator, which moves the interaction  $\psi^s$  from  $s'$  to  $s$  (in  $r$ ) at the lower

level; and (iii) the *trans*-operator,  $P$ , which acts at  $r$  causing the interaction to move up from the lower level to the initially observed level. The S-propagator formalism is particularly useful since:

1. It allows the quantitative *integration* of the elementary mechanisms, and thus a novel interpretation of biomedical knowledge in a hierarchical framework, e.g. the physiological effect of molecules [2];
2. It allows not only the *horizontal integration* through the D-FBS, e.g. the dynamic couplings between vascular and nervous system (the role of glial cells), but also the *transversal integration* through the D-FBS and the O-FBS, e.g. *predictable* lethal collateral effects;
3. Each of the *trans*-operators corresponds to one or more mathematical models that can be readily adapted to a general, global model of the biological system investigated.
4. The corresponding computing system (patented) works using the rigorous results of mathematical numerical analysis, and acts as a database of models, re-unifying disjoint domains of biology. It constitutes an “organized envelope” for specific mathematical models.

## **Reference**

G. A. Chauvet, *Theoretical systems in biology*, vol III, Pergamon Press (1996); G.A. Chauvet, *J. Integr. Neurosc.*, 1,1, 31-68 (2002).